Modelling Viking Era Water Ice Clouds

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Outline

- Background
- Goals
- Technique
- Results
- Future Work

Background

- Water ice clouds were present in the Martian atmosphere during the Viking era (Tamppari et al., 1999)
  - Identified via T_{11}-T_{20}
    - surface emissivities (Christensen, 1998) must be considered

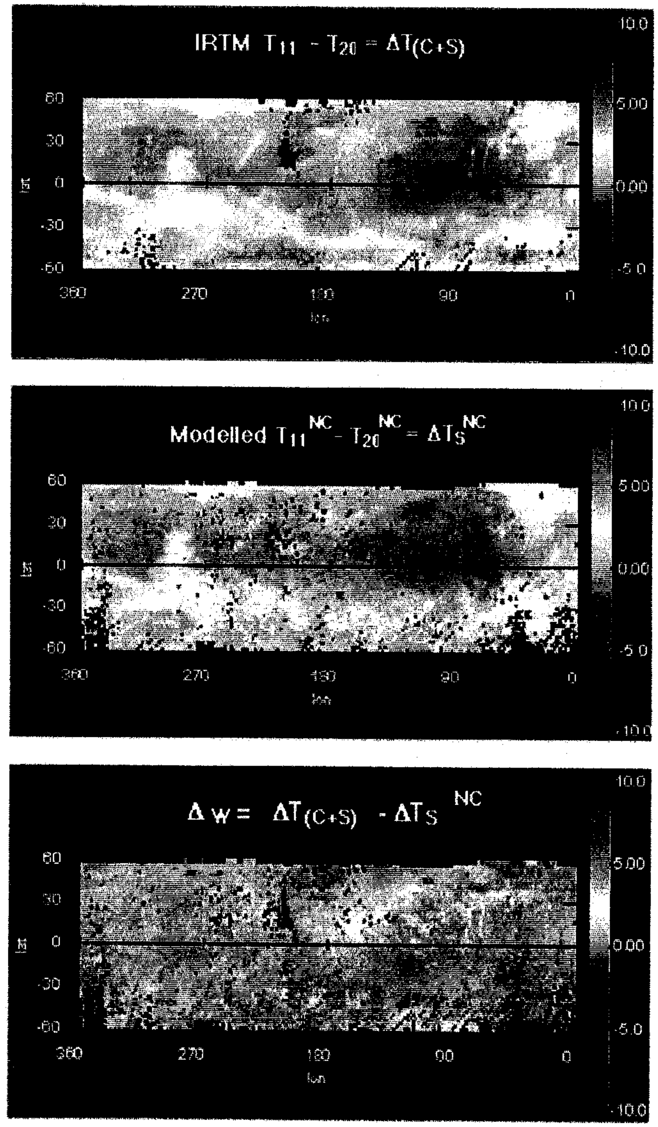
Detection of clouds in infrared

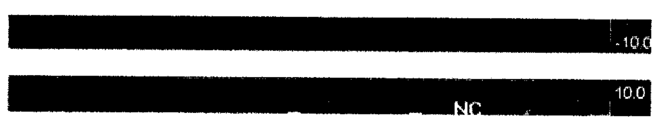
- Temperature contrast
- Spectral contrasts affected by
  - water ice clouds
  - surface spectral emissivities
  - dust

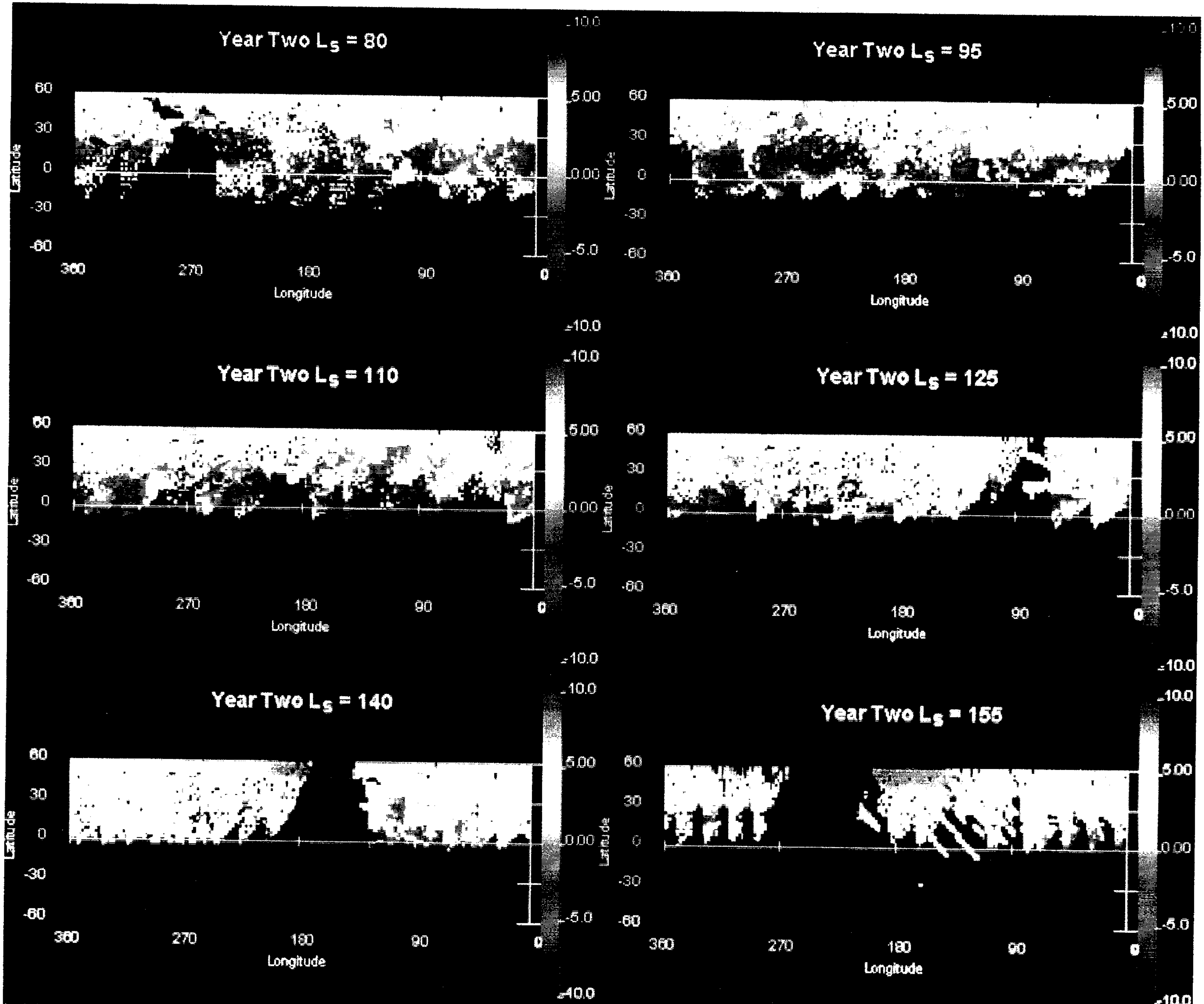
Spectral ε correction

- Raw IRTM T_{11}-T_{20} maps produced
- Modelled IRTM T_{11}-T_{20} maps produced
  - ε correction applied (Christensen, 1998)
  - surface thermal model (Paige et al., 1994)
- Residual cloud maps produced
  - $\Delta_w = (T_{11} - T_{20})_{raw} - (T_{11} - T_{20})_{modelled}$

Year One: Ls =[20,35]







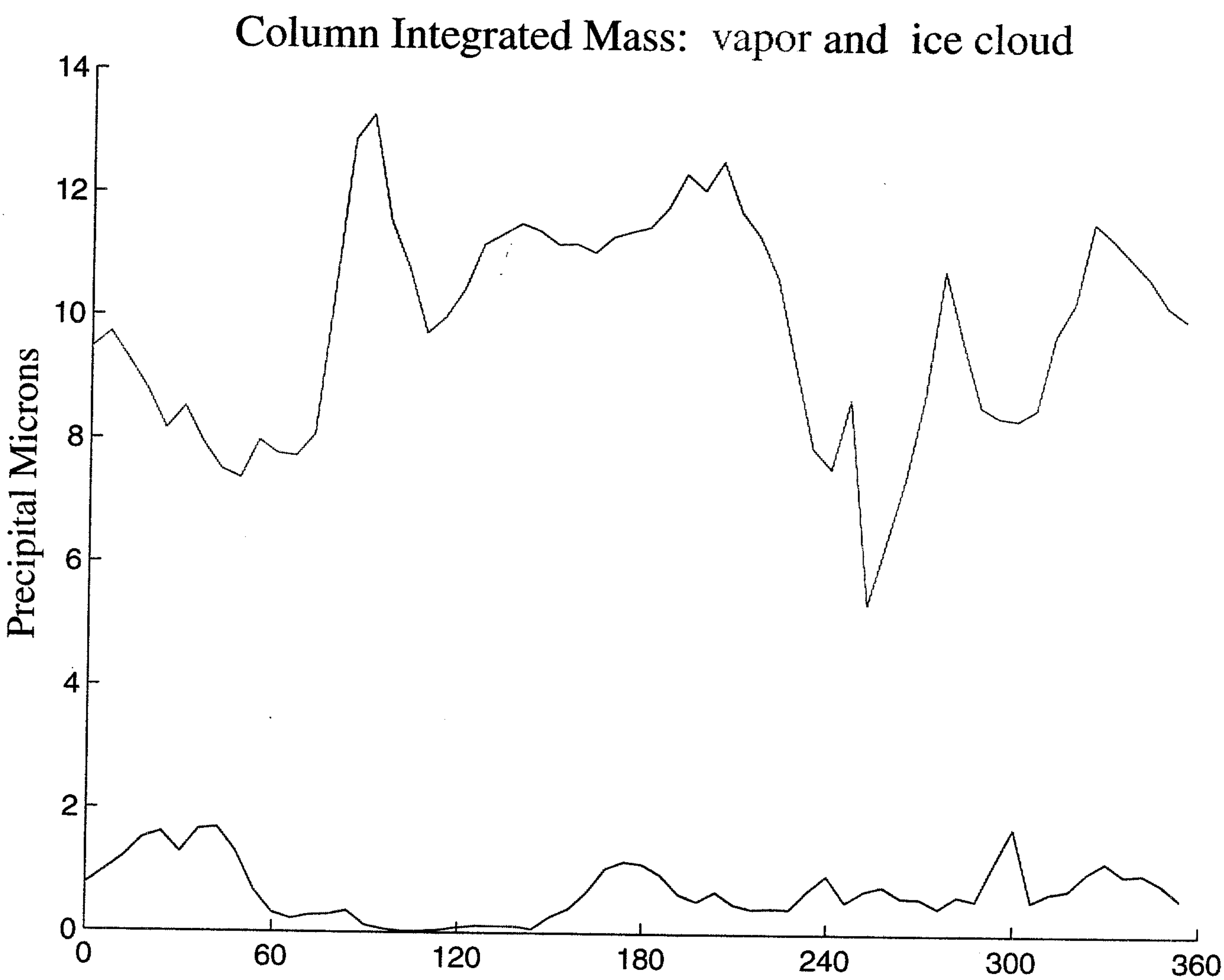
Year Two Ls = 80
Year Two Ls = 95
Year Two Ls = 110
Year Two Ls = 125
Year Two Ls = 140
Year Two Ls = 155
Latitude
Longitude
60
30
0
-30
-60
360
270
180
90
0
10.0
5.00
0.00
-5.0
-10.0

Goals

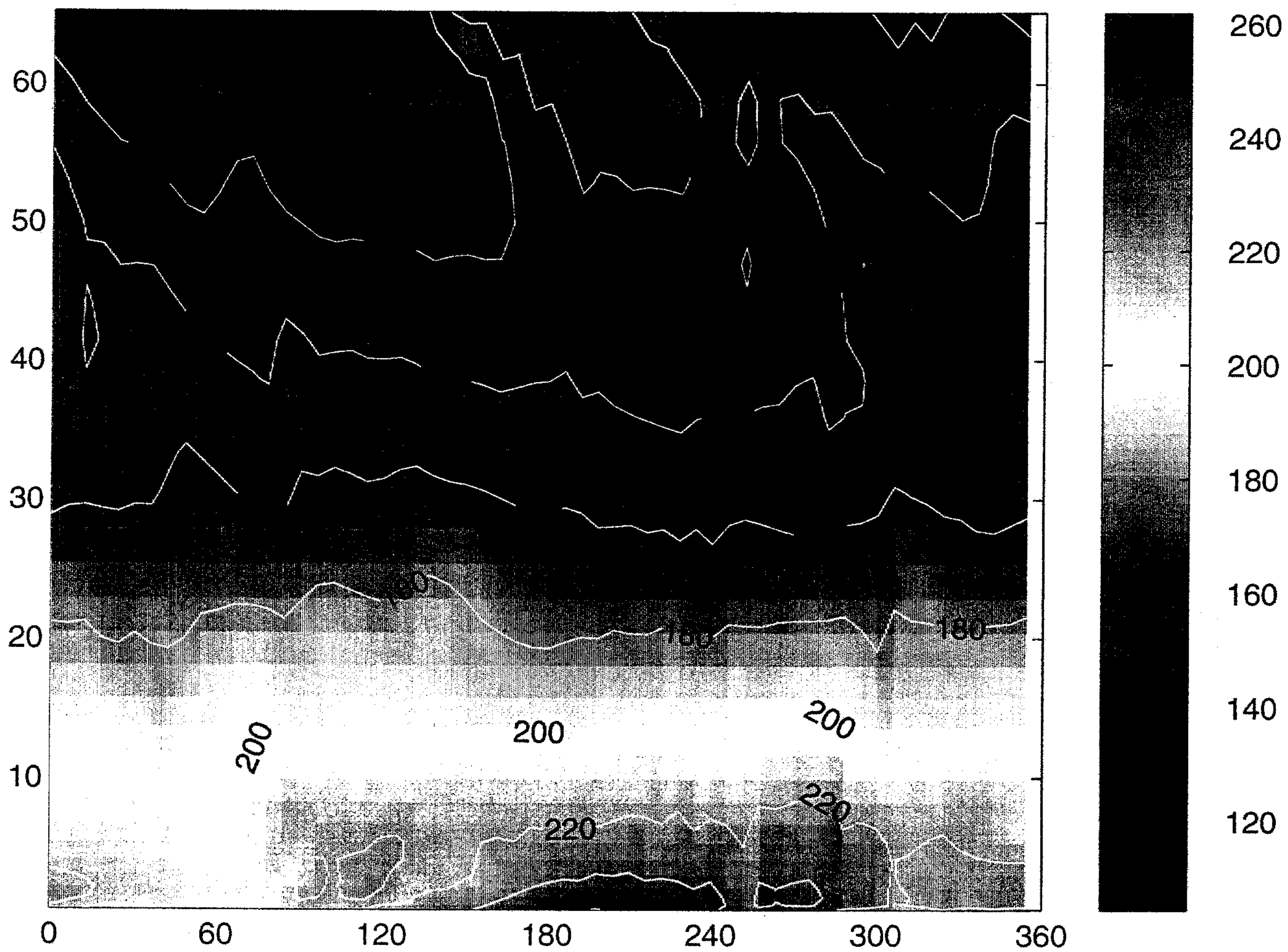
- Determine opacity and temperature of Viking era water ice clouds (Tamppari et al., 1999)
- Determine altitude of clouds
  - use simulated temperature profiles
- Determine water content of clouds
  - correlate with water vapor
  - overall water behavior

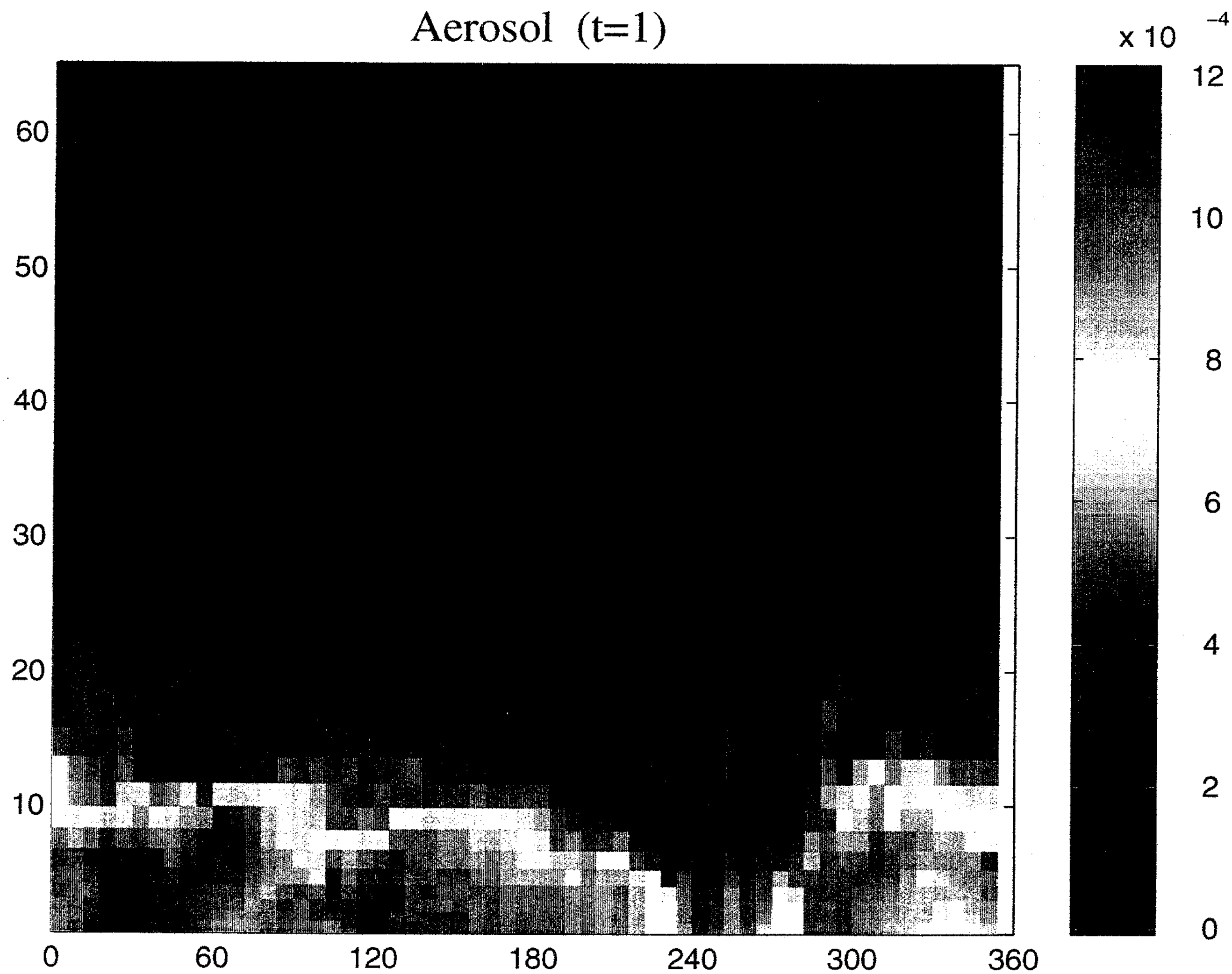
Technique

- Utilize GFDL MGCM
- Create column output for realistic Martian atmosphere
  - produces reasonable column integrated water vapor amount, T profile, dust profile
- Radiative transfer
  - incorporates surface ε_λ
  - uses MGCM column atmosphere calculations
  - calculate synthetic T_λ
  - compare to IRTM measured T_λ


Column Integrated Mass: vapor and ice cloud
Precipital Microns
14
12
10
8
6
4
2
0
0
60
120
180
240
300
360

Temperature (t=1)





Aerosol (t=1)
x 10^-4
12
10
8
6
4
2
0
60
50
40
30
20
10
0
60
120
180
240
300
360

Previous work

- 1D, 2-layer dust, ice cloud model
  - underconstrained
    - sensitive to τ_i, T_i, τ_d, T_d, T_s, $r_m$ice
- MGCM provides constraint on τ_i, T_i, τ_d, T_d

Water ice cloud temperature and opacity modelling

- 2-layer model
  - water ice cloud over dust cloud
- Fixed
  - Surface emissivities (Christensen, 1998)
  - Emission angle (data)
  - T_s (thermal model; Paige et al., 1994)
- Variables
  - T_d, τ_d, T_i, τ_i ranges
  - r_m^{ice} (4 sizes used)
  - r_m^{dust} (Clancy et al., 1995; Toon et al., 1977)

Modelling results

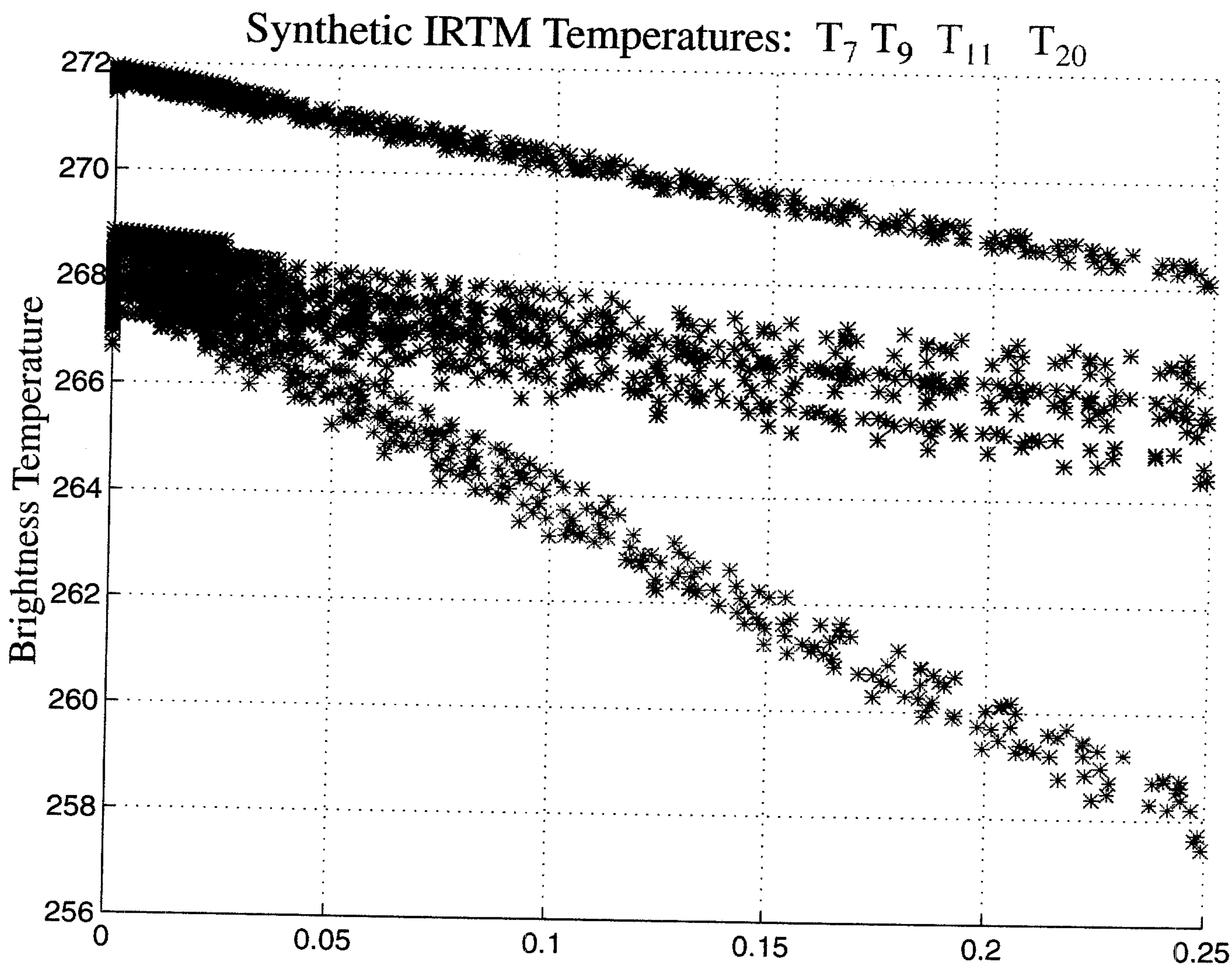
- Must model dust
  - cannot get good fits without it
- Sensitivities
  - T_s
    - often have to change from original surface thermal model derived
    - change of 1 K can mean $|T_\lambda^{meas} - T_\lambda^{mod}| > 1$ K
  - r_m^{ice} ; very sensitive, but possibly still bounded
  - r_m^{dust} ; not sensitive

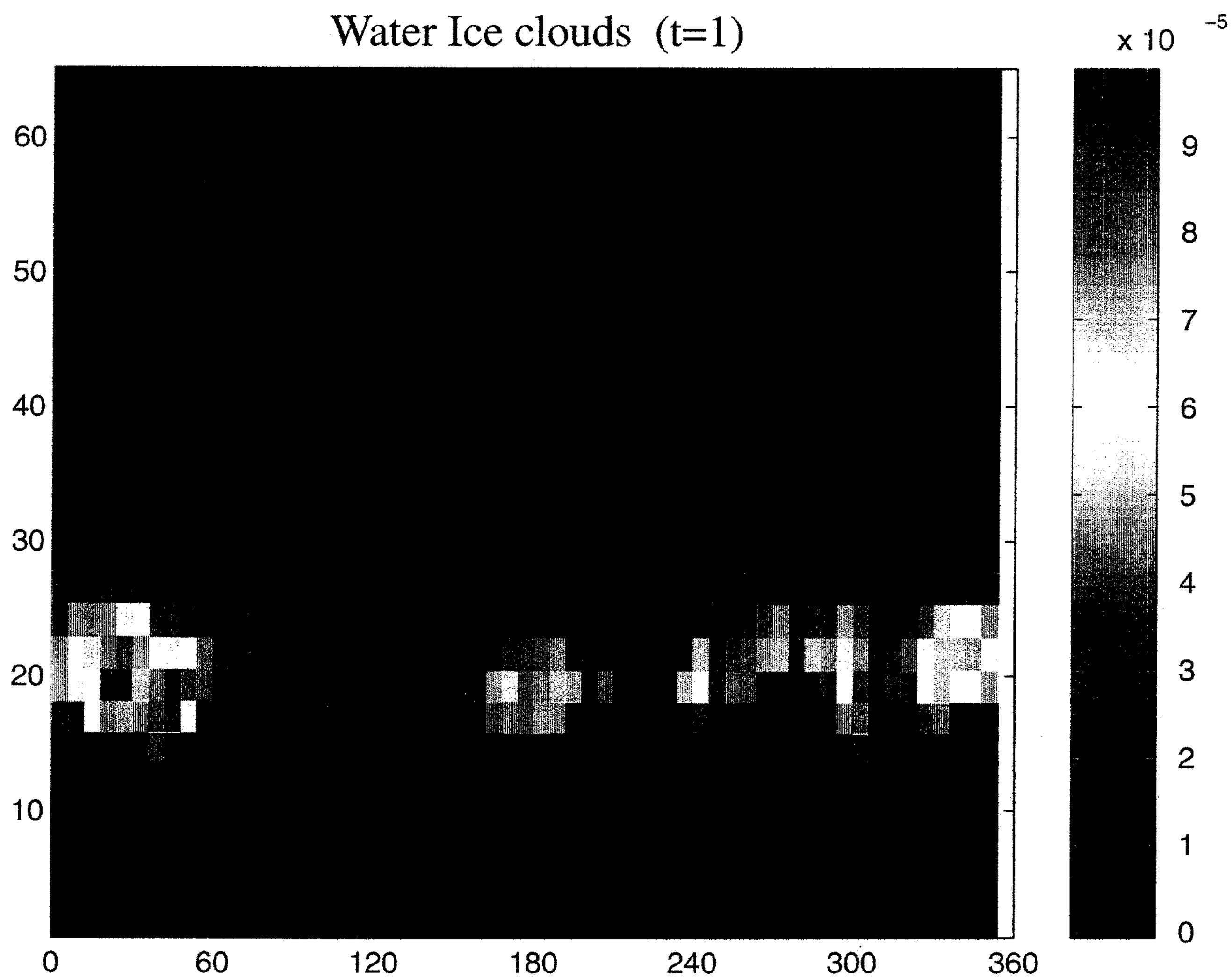
Approach

- Case study: N. Summer (L_s-95-110)
  - low dust time period
  - lat=17N, lon=315W
  - water ice clouds present
  - no special topography

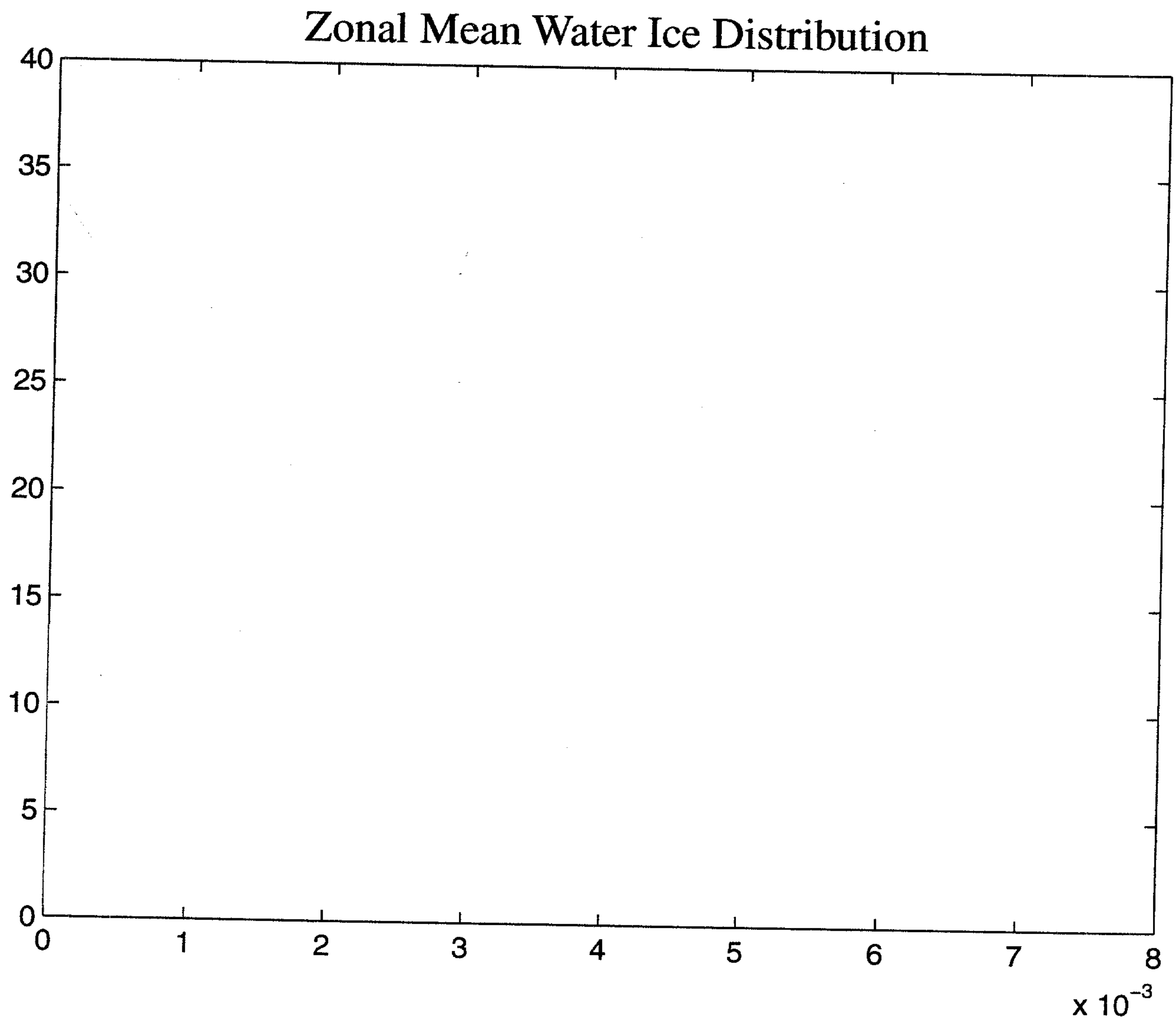
Results

- Best fit when
  - ➢ $\tau_i = 0.1$
  - ➢ $T_i = 180$ K
  - ➢ $h_i = 20$ km
- senstivity: dust, T_s, r_m^{ice}


Synthetic IRTM Temperatures: T_7 T_9 T_{11} T_{20}
Brightness Temperature
272
270
268
266
264
262
260
258
256
0
0.05
0.1
0.15
0.2
0.25



Water Ice clouds (t=1)
x 10^-5
60
50
40
30
20
10
0
60
120
180
240
300
360
9
8
7
6
5
4
3
2
1
0


Zonal Mean Water Ice Distribution
40
35
30
25
20
15
10
5
0
0
1
2
3
4
5
6
7
8
x 10^{-3}

Future Work

- Enhance technique to process all Viking IRTM-derived clouds
  - ➢ determine τ, T, h
    - – systematically
    - – self-consistently